A TAXONOMIC REVISION OF THE *SYRINGA PUBESCENS* COMPLEX (OLEACEAE)[1]

Chen Jin-Yong,[2,3,4] *Zhang Zuo-Shuang,*[3] *and Hong De-Yuan*[2]

ABSTRACT

Over 19 species and numerous infraspecific taxa have been described in the *Syringa pubescens* Turcz. complex (Oleaceae), and the taxonomy of this complex has been controversial. To provide a rational taxonomic revision of the complex, field observations were undertaken across China and 14 populations were sampled. The principal coordinate and principal components analyses and general statistical analysis evaluate the significance of characters for taxonomy. As a result, one species is recognized, with three subspecies: *Syringa pubescens* subsp. *pubescens* Turcz., subspecies *microphylla* (Diels) M. C. Chang & X. L. Chen, and subspecies *patula* (Palib.) M. C. Chang & X. L. Chen. *Syringa meyeri* C. K. Schneid. is treated as a new synonym of *S. pubescens* subsp. *pubescens*, and *S. julianae* C. K. Schneid. and *S. meyeri* var. *spontanea* M. C. Chang as new synonyms of *S. pubescens* subsp. *microphylla*. Lectotypes for *S. microphylla* Diels, *S. dielsiana* C. K. Schneid., and *S. venosa* Nakai are designated here.

Key words: Oleaceae, population sampling, statistics, *Syringa pubescens* complex, *Syringa*, taxonomic revision.

The *Syringa pubescens* Turcz. complex (Oleaceae) belongs to section *Syringa* L. ser. *Pubescentes* (C. K. Schneid.) Lingelsh. (Lingelsheim, 1920; Chang, 1992). It differs from the other species in the series in having purple anthers and verrucose fruits, and is widely distributed in China and the Korean Peninsula.

Turczaninow (1840) briefly described *Syringa pubescens* as new, stating that it grew in the mountains of northern China. From 1900 (Palibin, 1900) to 1990 (Chang & Chen, 1990), more than 17 species and additional infraspecific taxa were described. A total of 19 new species and varieties have so far been described in the complex. The taxonomy of this complex has been controversial. McKelvey (1928) recognized seven species, whereas Chang (1992) and Chang and Green (1996) recognized two species, *S. pubescens* and *S. meyeri* C. K. Schneid. The former species comprises four subspecies: subspecies *pubescens* Turcz., subspecies *patula* (Palib.) M. C. Chang & X. L. Chen, subspecies *julianae* (C. K. Schneid.) M. C. Chang & X. L. Chen, and subspecies *microphylla* (Diels) M. C. Chang & X. L. Chen, which overlap in distribution in China (Chang, 1992). *Syringa pubescens* subsp. *microphylla* includes three varieties: *microphylla*, *flavoanthera* (X. L. Chen) M. C. Chang, and *potaninii* (C. K. Schneid.) P. S. Green & M. C. Chang. *Syringa meyeri* consists of two varieties, variety *meyeri* and variety *spontanea* M. C. Chang. However, Qin (1998) raised *S. meyeri* var. *spontanea* to specific rank as *S. spontanea* (M. C. Chang) X. K. Qin, considering it to have smaller, suborbicular, and palmately 5-veined leaf blades and densely pubescent branchlets. Therefore, three species, four subspecies, and three varieties are recognized for the *S. pubescens* complex in the most recent literature.

Indumentum on leaf surfaces, inflorescence rachises, and calyces has been frequently used to describe new species in *Syringa*. For instance, Komarov (1901) and Schneider (1910) stated that *S. velutina* Kom. and *S. potanini* C. K. Schneid. differed from *S. pubescens* in being hairy on both sides of the leaves. Nakai (1913) and Skvortzov and Wang (1955) described *S. palibiniana* Nakai and *S. wulingensis* Skvortsov & W. Wang based on their glabrous leaves, different from *S. velutina*. Other characters used by previous authors have included size of plants, inflorescences, and leaf blades; shape and venation pattern of leaf blades; length of corolla tubes; color of anthers; and position of anther insertion. For example, Chen et al. (1989) described *S. microphylla* var. *flavoanthera* X. L. Chen as new based on its yellow anthers.

Taxonomists have described new taxa based on a limited number of specimens, which caused quite a few superfluous names. For instance, Schneider (1905,

---

[1] The authors are grateful to the National Natural Science Foundation of China (grant 30500036) and the Beijing Administrative Bureau of Landscape Architecture for support. We thank the curators of herbaria A, BM, E, FI, HIB, HNWP, IFP, K, LE, NWFC, P, SDFS, SDNU, SHM, TI, UPS, and WUK for permission to examine the specimens or for specimen loans.

[2] State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences, Xiangshan, Beijing 100093, People's Republic of China. hongdy@ibcas.ac.cn.

[3] Beijing Botanical Garden, Wofosi Road, Beijing 100093, People's Republic of China.

[4] Graduate School, Chinese Academy of Sciences, Beijing 100039, People's Republic of China.

doi: 10.3417/2006072

ANN. MISSOURI BOT. GARD. 96: 237–250. PUBLISHED ON 7 JULY 2009.

1910) described *Syringa dielsiana* C. K. Schneid., *S. potaninii*, and *S. giraldiana* C. K. Schneid. as new from the Qinling Range in Shaanxi Province; these species were later lumped into one taxon by Chang and Chen (1990). New species in *Syringa* have been based on minor differences. For example, Tang (1941) described *S. trichophylla* Tang as new, although it is scarcely different from *S. microphylla* in the denser indumentum on leaves and anther nearer to corolla throat. The objective of the present study is to examine the variation of morphological characters based on field observations, population sampling, and subsequent multivariate analysis, and finally to taxonomically revise the *S. pubescens* complex.

Materials and Methods

A total of 14 populations were sampled across China (Table 1). In addition, a large number of herbarium specimens collected from the Korean Peninsula and Inner Mongolia, Liaoning, Hebei, Beijing, Shanxi, Shaanxi, Shandong, Henan, Hubei, Chongqing, Gansu, and Qinghai of China were examined from the following herbaria: A, BM, E, FI, HIB, HNWP, IFP, K, NWFC, P, PE, SDFS, SDNU, SHM, TI, UPS, and WUK. The characters used for the analysis were coded as in Appendix 1.

PRINCIPAL COORDINATE AND PRINCIPAL COMPONENTS ANALYSES

In addition to the 14 populations mentioned above, specimens from the Korean Peninsula were used to represent the Korean population (KOR) and specimens from Hubei and Chongqing to represent another population (OTH). The specimens determined as *Syringa meyeri* were represented as MEY in the analysis. The type specimen and other herbarium specimens were incorporated into the analysis to ensure ca. 10 individuals in each group. The numerical data set was transformed by standardization. By calculating Gower similarity coefficient, the principal coordinate analysis (MVSP 3.0 software; Kovach Computing Service, Anglesey, Wales) was used to plot the individual distributions in the 17 populations or data sets. By using principal components analysis (PCA), the characters contributing mostly to the first three principal components were selected for further variation analysis in order to evaluate their taxonomic value.

CHARACTER VARIATION ANALYSIS

For selected characters, the range, mean value, and standard deviation of each population were calculated to determine whether the morphological variation was continuous or discontinuous among the populations.

Character Analysis and Results

The principal component analysis showed that the first coordinate accounted for 20% of the variation and the next two coordinates, 14% and 8.4%, respectively. The main characters contributing to the first component included the length and width of leaf blades, indumentum on inflorescence rachises and calyces, diameter of corolla throats, and anther position on corolla tubes. The characters including length and shape of corolla tubes (CTS), and distance between anthers and corolla throat contribute mostly to the second component. The third component contributes much less than the first two components.

The characters contributing mostly to the first two principal components and those used by previous authors for describing new taxa are analyzed below.

SIZE OF LEAF BLADES

This is a major character in the PCA. According to our observations, leaf blades varied continuously in size among populations, but they were somewhat larger in populations KOR, DAN, and LIA (4.4–8.2 × 2.5–5.5 cm) than in other populations (1.5–6 × 1.1–3.3 cm) (Fig. 1A, B). The group comprising KOR, DAN, and LIA corresponds to Green and Chang's (1995) *S. pubescens* subsp. *patula*.

SHAPE OF LEAF BLADES

Shape of leaf blades was converted into the ratio of length to width in our analysis for effective comparison. The character is less important as shown in the PCA, and its variation ranges overlap considerably among populations (Fig. 1C).

INDUMENTUM ON LEAF SURFACES

Because the indumentum is a very variable character, we used five grades to describe it (Appendix 1). The analysis of all population samples and herbarium specimens showed that the leaves in most populations are usually glabrous on the adaxial surface of leaves except in KOR, QIN, OTH, and TIA, which have both glabrous and densely hispidulous forms (Table 2). The abaxial surface of the leaves is usually sparsely pubescent (grade 1 or 2) except in KOR, QIN, OTH, and TIA, which also have densely pubescent forms, and in JIN and SHM, which also have glabrous forms (Table 2). Plants from the Qinling Range of China and the Korean Peninsula tend to

Table 1. The *Syringa pubescens* complex in China. Fourteen populations and three data sets (*) are listed approximately from east to west in China and Korea.

Population code	Population site	Voucher collection	Population size (n)
KOR*	Specimens from the Korean Peninsula	*E. H. Wilson 8602*, K, PE	15
DAN	Liaoning Prov.: Dandong, Mt. Wulong, sunny slope or semi-shade deciduous forest, 400–600 m	*J. Y. Chen 04108*, PE	8
LIA	Liaoning Prov.: Mt. Fenghuang; Mt. Qianshan, shady deciduous forest or on the summit, 500–600 m	*J. Y. Chen 03246*, PE	7
JIN	Liaoning Prov.: Jinzhou, Mt. Dahei, sunny, open thicket at the summit, 400 m	*J. Y. Chen 03118*, PE	15
WUL	Hebei Prov.: Mt. Wuling, semi-shade forest, 1000–1600 m	*J. Y. Chen 03180*, PE	17
BAI	Beijing: Mt. Baihua, shady deciduous forest, 1200–1700 m	*J. Y. Chen 04135*, PE	12
HEN	Shanxi Prov.: Mt. Hengshan, semi-shade deciduous forest or open place at the summit, 1400–2000 m	*J. Y. Chen 03208*, PE	8
SHM	Shanxi Prov.: Taiyuan, Mt. Tianlong, semi-shade forest verge, 1300 m	*J. Y. Chen 04102*, PE	3
TAI	Shandong Prov.: Mt. Taishan, sunny, open thicket or forest margin, 1400–1500 m	*J. Y. Chen 04207*, *04210*, PE	4
OTH*	Specimens from Hubei Prov. and Chongqing	*Z. E. Zhao 2055*, HIB	11
HUA	Shaanxi Prov.: Mt. Huashan, sunny, open slope or semi-shade thicket, 1600–2000 m	*J. Y. Chen 03143*, *03153*, PE	16
QIN	Shaanxi Prov.: Mt. Taibai, shady deciduous forest or forest margin, 1200–1700 m	*J. Y. Chen 03021*, PE	5
ZHU	Shaanxi Prov.: Zhuque National Forest Park, moist, semi-shade deciduous forest, 1700–1900 m	*J. Y. Chen 03158*, *03160*, PE	11
HUO	Shaanxi Prov.: Ningshan, Huoditang, semi-shade deciduous forest verge, 1900–2000 m	*J. Y. Chen 05091*, PE	4
TIA	Gansu Prov.: Tianshui, Putaoyuan, dry, sunny, open thicket, 1200 m	*J. Y. Chen 04036*, PE	10
KON	Gansu Prov.: Mt. Kongtong, shady deciduous forest, 2000 m	*J. Y. Chen 03171*, PE	6
MEY*	Specimen determined as *Syringa meyeri*	*F. N. Meyer 23032*, A	4

have denser indumentum on both sides of the leaves than those from northern China. However, the indumentum density cannot be used to delimit taxa in the complex because of its continuous variation.

LEAF VENATION

The leaf venation of *Syringa* is generally pinnate, although palmate venation has been described in *S. meyeri* and *S. meyeri* var. *spontanea* (Chang & Chen, 1990; Green & Chang, 1995). Having critically examined the type specimen of *S. meyeri*, we found that the basal two pairs of veins do not connect to form palmate venation, although the veins are close (Fig. 2A). Similarly, there are both palmate and pinnate veins in the type specimen of *S. meyeri* var. *spontanea* (Fig. 2B). Meanwhile, a venation similar to that of *S. meyeri* and *S. meyeri* var. *spontanea* frequently exists in the populations from Shandong and Shanxi provinces. Therefore, leaf venation is not a diagnostic character to differentiate *S. meyeri* and *S. meyeri* var. *spontanea* from the other species.

INDUMENTUM ON INFLORESCENCE RACHISES AND CALYCES

This was an important character as shown in the PCA. The populations KOR, SHM, and HUA have inflorescence rachises varying from glabrous to densely hairy, whereas in DAN, WUL, BAI, and HEN they are mostly glabrous and densely hairy in the remaining populations (Table 2). Similarly, the populations DAN, LIA, WUL, BAI, HEN, and MEY have almost glabrous calyces, TIA has hairy calyces, and the remaining populations have both glabrous and hairy forms (Table 2).

SHAPE OF INFLORESCENCE RACHISES

The shape of inflorescence rachises is difficult to distinguish in practice, especially when inflorescence

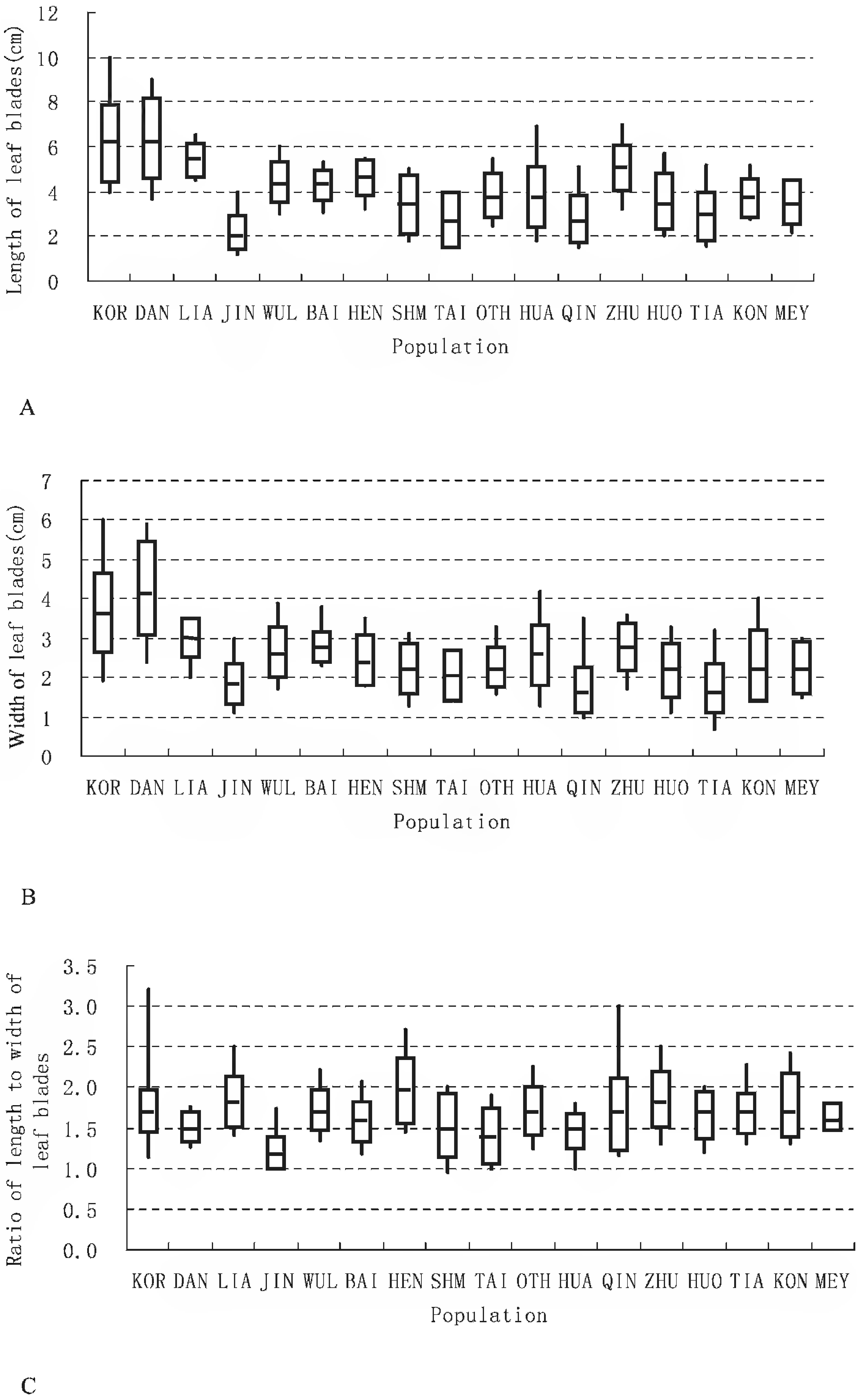

Figure 1. Box plots depicting morphological variability of leaf blades in the *Syringa pubescens* Turcz. complex. —A. Lengths of leaf blades. —B. Widths of leaf blades. —C. Length to width ratios of leaf blades. Character ranges include means and standard deviations. Abbreviations of the 17 populations are explained in Table 1.

Table 2. The number of individuals of each indumentum coverage (see Appendix 1) on leaf surfaces, inflorescence rachises, and calyces among populations of the *Syringa pubescens* complex.

	Adaxial leaf surfaces					Abaxial leaf surfaces					Inflorescence rachises					Calyces				
Population	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
KOR	16	1	4	2	3			17	4	5	8	1	8	6	3	17	1		2	5
DAN	8						7	1			6	2				8				
LIA	9						2	7					4	2	3	6	3			
JIN	18					4	8	6						3	15	3	1		4	10
WUL	19					1	3	15			19					19				
BAI	14						1	13			10	1	2	1		13	1			
HEN	9						5	4			6	1	2			9				
SHM	7	1				2	2	4			4	1			3	5	1		1	1
TAI	18	1				1	7	11			1	3	7	8		13	1	1	4	
OTH	4	6	1	1	1	1	3	6	3		1		3	2	7	8		1	2	2
HUA	18					1	6	10	1		11			2	5	14	1	1	2	
QIN	7	4	4	3	1		1	8	7	3			1	3	15	2	1		3	13
ZHU	8	2						10				3	4	3		7	2	1		
HUO	9						3	6					2	7		4		1	4	
TIA	11	1		3			4	8		3			2	5	8		1	2	5	7
KON	6						1	5					2	3	1	3	2		1	
MEY	4						1	3					3		1	4				

rachises are hairy. From our observations, inflorescence rachises are obviously 4-angled in the populations DAN, LIA, BAI, WUL, HEN, and SHM, and are 4-angled, terete or subterete in the remaining populations.

SHAPE OF COROLLA TUBES

The shape of the corolla tube is quite subjective. We used an alternative method in the analysis so that different populations could be compared. First, we measured the diameter of corolla throats, which varied from 1.6 to 2.5 mm in the populations KOR, DAN, and LIA, 0.9–1.6 mm in JIN, SHM, TAI, QIN, HUO, and TIA, and 1.3–2.2 mm in the others (Fig. 3A). Then we calculated the ratio CTS (Appendix 1), which varied from 0.12 to 0.21 in the populations KOR, DAN, and LIA, and less than 0.12 in the others (Fig. 3B). Therefore, the populations KOR, DAN, and LIA are quite distinctive in the complex.

COLOR OF ANTHERS

Anthers are usually purple in this complex. Our extensive examination found only three collections with yellow anthers, i.e., *G. Giraldi 740* (FI), *T. N. Liou 190* (IFP), and *S. patula* cultivated in Beijing Botanical Garden, which has both yellow and purple anthers on the same individual. Thus, we assume that yellow anthers are occasionally variant and not a good character for the taxonomy of this complex.

ANTHER INSERTION ON THE COROLLA TUBE

From our observations, the distance between anthers and corolla throat is less than 1 mm in the populations KOR, DAN, LIA, OTH, ZHU, and HUO, more than 1 mm in JIN, WUL, BAI, HEN, SHM, HUA, and KON, and 0.4–2 mm in TAI, QIN, and TIA, showing continuous variation among the populations (Fig. 3C). Therefore, the distance between anthers and corolla throat is not effective for delimiting taxa.

CAPSULES

The capsule apices in many populations (DAN, LIA, JIN, WUL, HEN, OTH, HUA, ZHU) are both obtuse and acute, although mostly acute. Thus, the capsule apex is insignificant in the taxonomy of the complex.

The results of principal coordinate analysis (PCO), PCA, and character variation analysis all indicate that only one species can be recognized in the complex, since there are no obvious gaps among the populations in the PCO plot (Fig. 4) and no character shows discrete variation among the populations. However, three entities can be recognized in this complex. It can be seen from the first two coordinates (Fig. 4) that the populations KOR, DAN, and LIA form a loose group, WUL, BAI, and HEN form a second, JIN, QIN, and TIA form a third, while the others (including TAI, HUO, KON, and MEY) are intermediate. Specimens especially from SHM, HUA, ZHU, and OTH are scattered among the above three groups.

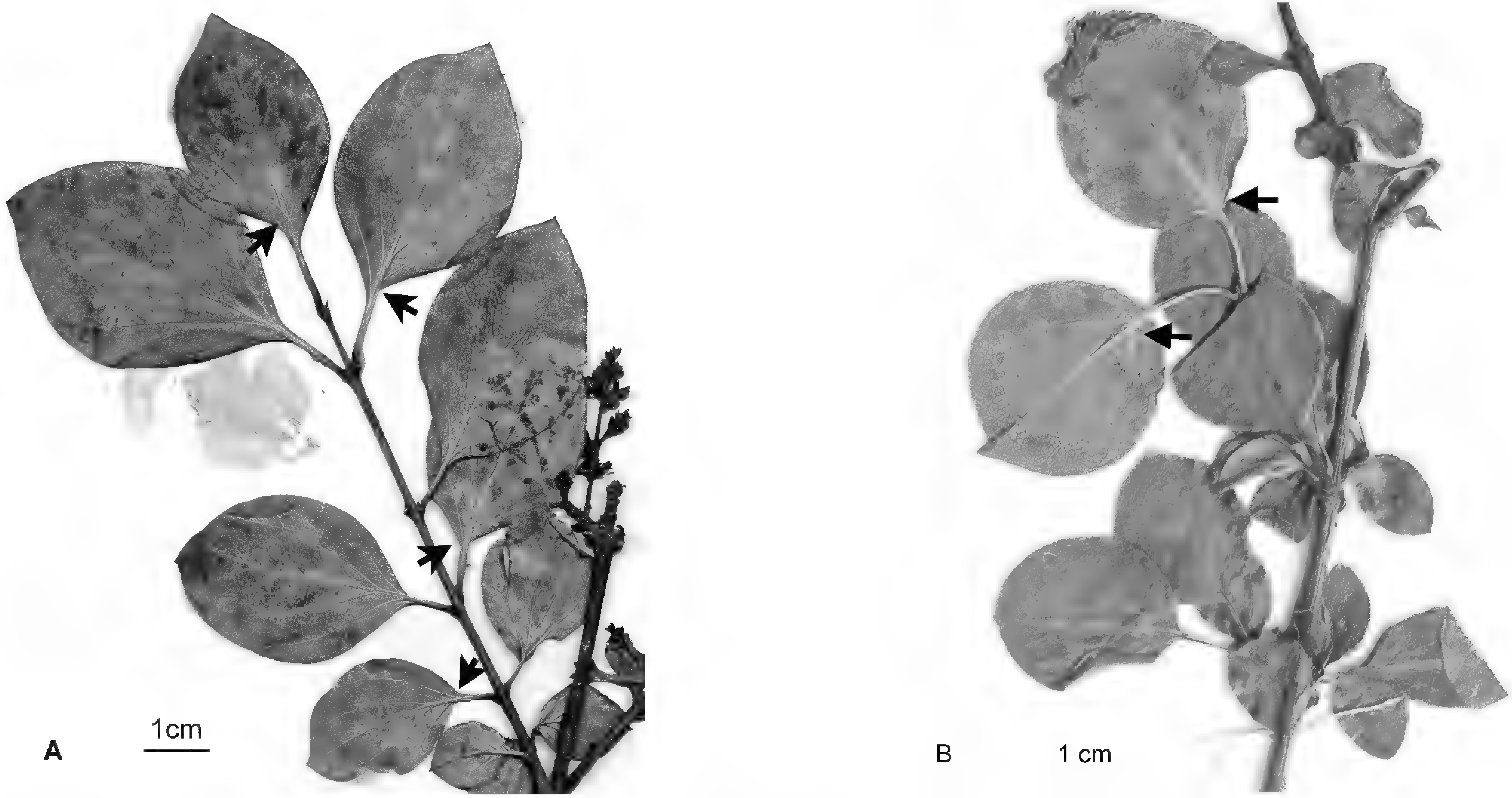

Figure 2. —A. *Syringa meyeri* C. K. Schneid., *F. N. Meyer 23032* (holotype, A). —B. *Syringa meyeri* var. *spontanea* M. C. Chang, *J. Y. Chen 03121* (PE), collected from the type locality (Jinzhou, Liaoning Province). Note that the leaf venation is not exactly palmate (see arrows).

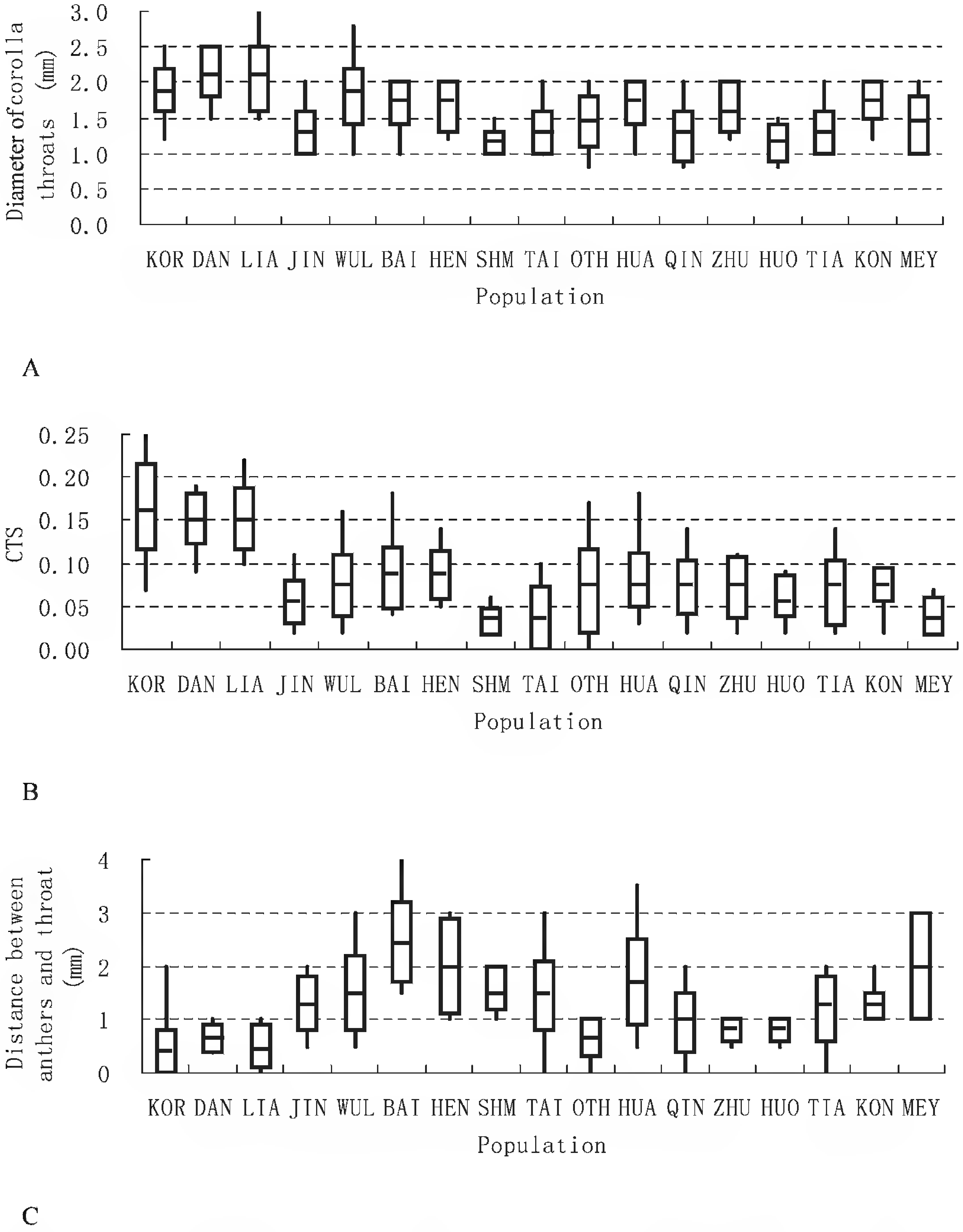

Figure 3. Box plots depicting morphological variability of corollas in the *Syringa pubescens* Turcz. complex. —A. Diameter of corolla throats. —B. Shape of corolla tubes (CTS), expressed as [(diameter of corolla throat – diameter of corolla base) / length of corolla tube]. —C. Comparison of distance between anthers and corolla throat. Character ranges include means and standard deviations. Abbreviations of the 17 populations are explained in Table 1.

Because the populations SHM and HUA show a gradual transition from the third group to the second in the PCO plot, we chose all the specimens from these regions and depicted various characters and altitudes on the plot to see the relationship between altitudes and characters (Fig. 5). It is shown that the shape and indumentum of inflorescence rachises and the length of leaf blades are related to altitudes in both regions. In the population HUA, plants above 1800 m have inflorescence rachises 4-angled and

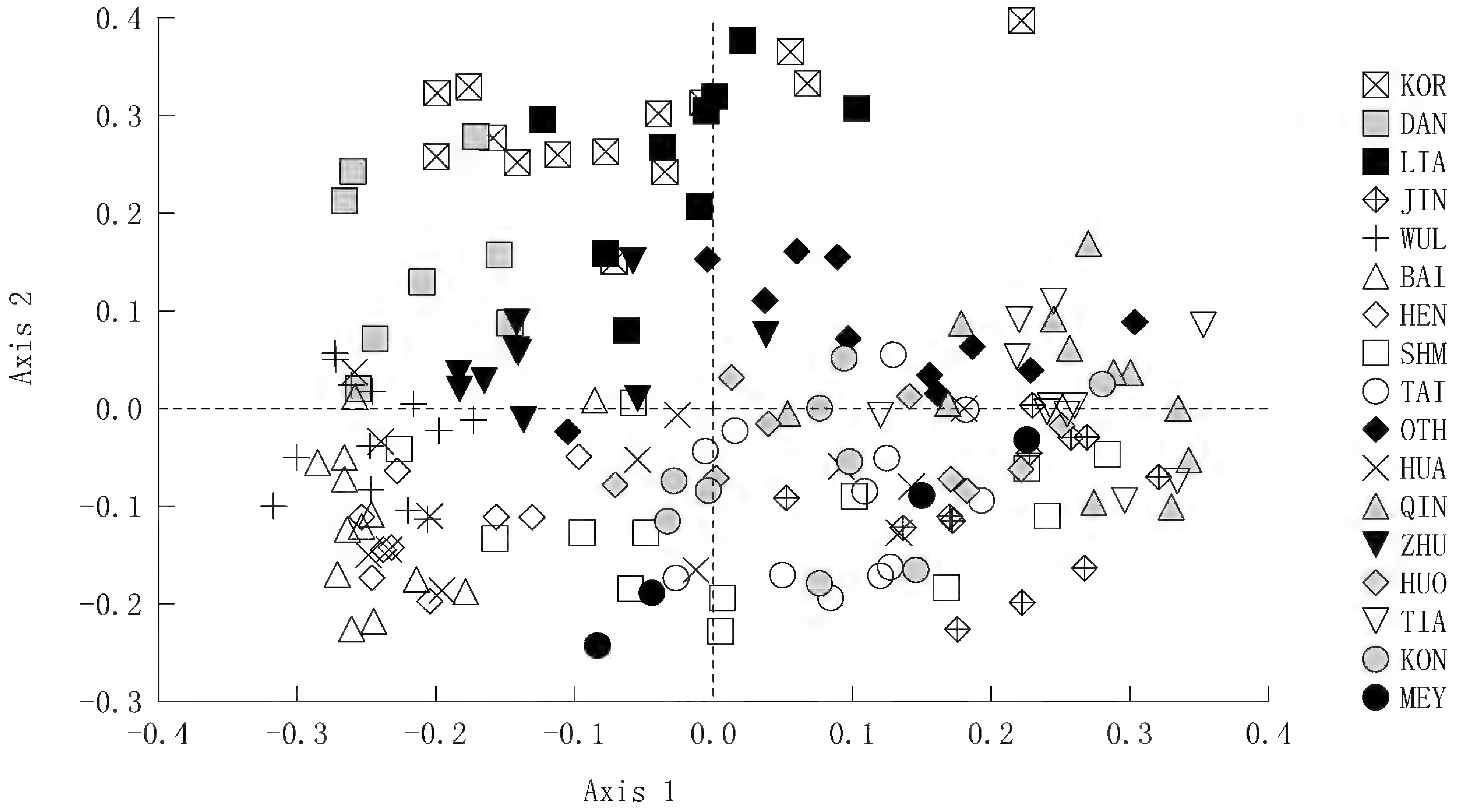

Figure 4. Scatter plot of principal coordinates 1 against 2 for the *Syringa pubescens* complex. Characters contributing to axis 1 include indumentum on inflorescence rachises and calyces. The length and shape of corolla tube and the distance between anthers and corolla throat contribute to axis 2.

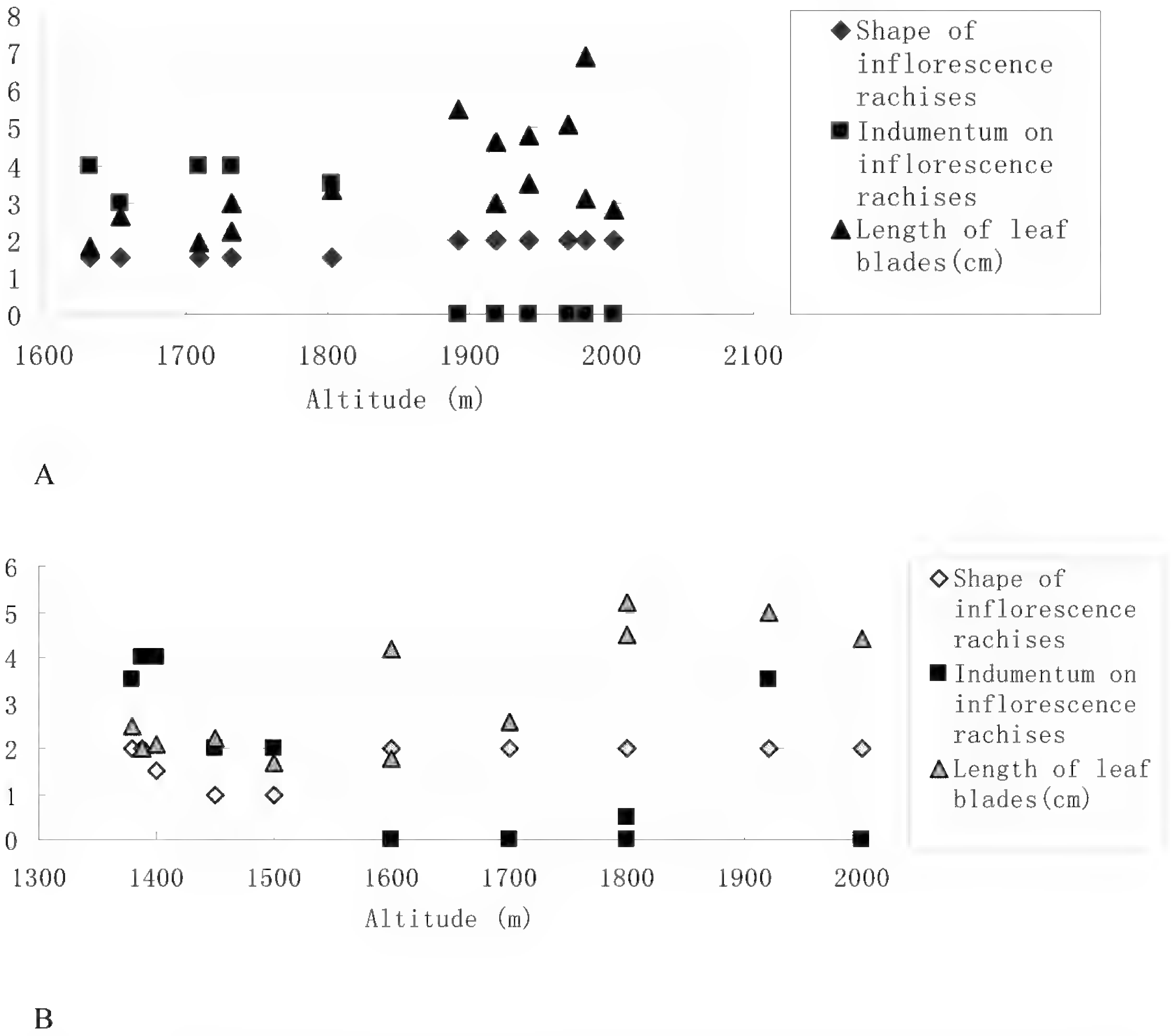

Figure 5. Scatter plots of morphological character against elevational change. —A. Leaf blade length, shape, and the pubescence of the inflorescence rachis (y axis) are plotted against elevational change (x axis) on Mt. Huashan, Shaanxi Province, China (HUA). —B. Morphological characters as in A (y axis) are plotted against elevational change (x axis) for localities in central and southern Shanxi Province in China.

glabrous and leaf blades often more than 3 cm long, whereas those below 1800 m have inflorescence rachises subterete and hairy and leaf blades commonly less than 3 cm long (Fig. 5A). In the population SHM (here the population was enlarged, including exsiccatae from central and southern Shanxi Province), plants from 1600 m and up have inflorescence rachises almost glabrous and 4-angled and leaf blades usually more than 4 cm long, while those below 1600 m tend to have inflorescence rachises hairy and subterete and leaf blades less than 3 cm long (Fig. 5B). The results indicate that plants from higher altitudes of eastern Shaanxi (HUA) and southern and central Shanxi (SHM) resemble plants from northern China (WUL, BAI, HEN), whereas those from lower altitudes resemble plants from western China (KON, TIA, QIN, etc.)

Therefore, three subspecies are recognized in the complex. The first subspecies includes the populations KOR, LIA, and DAN, which have leaf blades usually 4.4–8.2 cm long, corolla tubes funnel-shaped (CTS greater than 0.12), and throats usually 1.6–2.5 mm in diameter. These characteristics are in accordance with those of Chang and Chen's (1990) subspecies *patula*. This subspecies is distributed in the Korean Peninsula and northeastern China (Fig. 6). The second includes the populations WUL, BAI, HEN, and the high-altitude specimens from the populations SHM and HUA, which have inflorescence rachises 4-angled and glabrous and leaves generally 3.5–5.4 cm long. This corresponds to subspecies *pubescens*. It occurs in Inner Mongolia, Beijing, Hebei, northern Shanxi, and at higher altitudes in central and southern Shanxi and eastern Shaanxi

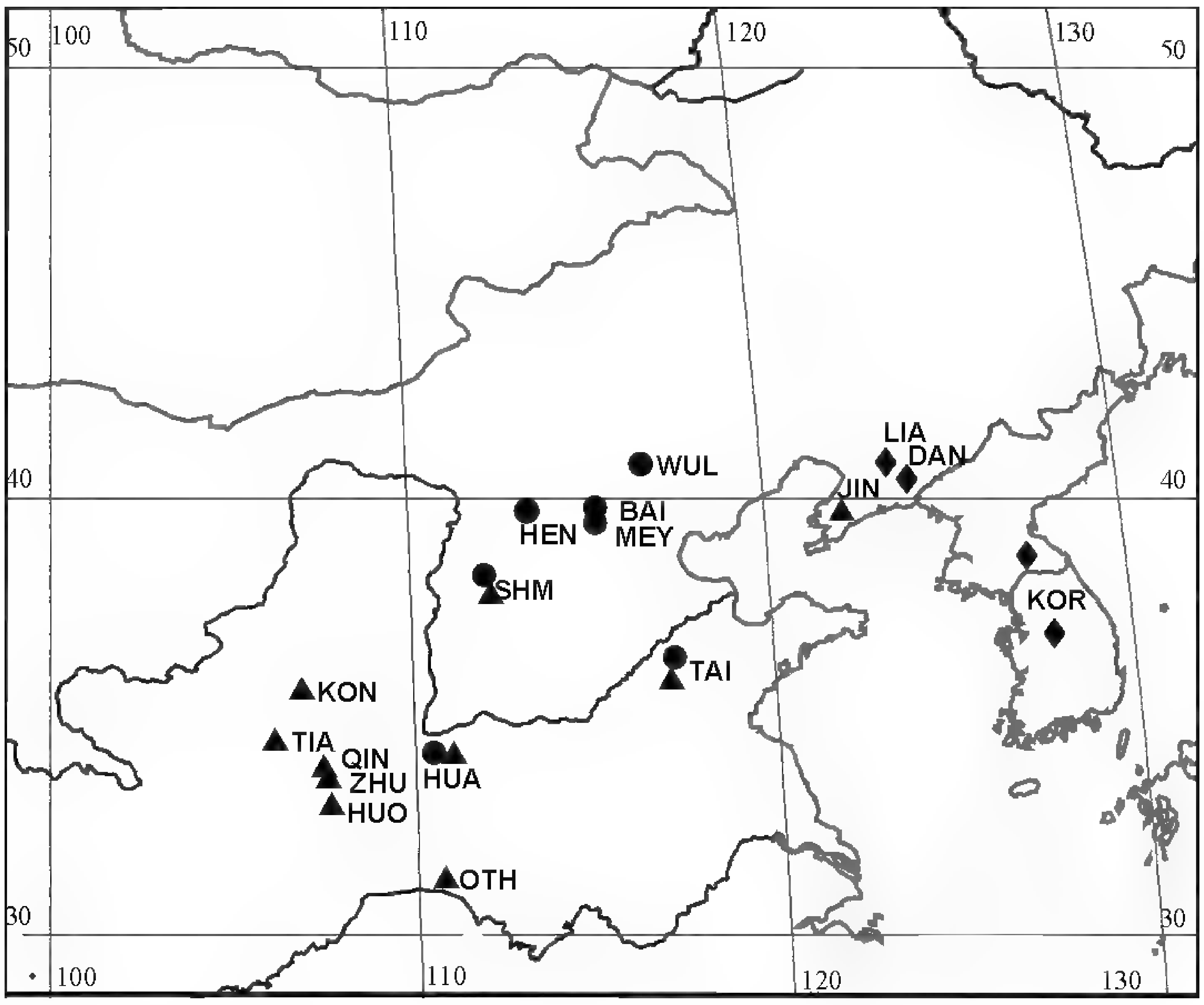

Figure 6. Distribution map of the 17 populations of the *Syringa pubescens* complex. Filled circle, subsp. *pubescens*; filled triangle, subsp. *microphylla*; filled diamond, subsp. *patula*.

provinces (Fig. 6). The third comprises the remaining populations, which have hairy, subterete or 4-angled inflorescence rachises, and usually 1.5–6 cm long leaf blades. The subspecies *microphylla* includes Chang and Chen's (1990) subspecies *microphylla* and subspecies *julianae* and Chang's (1990) *S. meyeri* var. *spontanea*. It grows at lower altitudes in central and southern Shanxi and in Shaanxi, as well as in Gansu, eastern Qinghai, Chongqing, western Hubei and Henan, Mt. Taishan of Shandong Province, and the Jinzhou region of Liaoning Province (Fig. 6).

Western Hubei is the type locality of *Syringa julianae*. Plants corresponding to descriptions of *S. julianae* are very rare in the wild and were not found in our fieldwork. Most specimens from this region (population OTH) are close to subspecies *microphylla* in the PCO plot (Fig. 4) except three sheets of *E. H. Wilson 2024*. Thus, plants from this region are still recognized as subspecies *microphylla* even though some extremes occur.

The population JIN was recognized as *Syringa meyeri* var. *spontanea* by Chang (1990) because its venation was close to that of *S. meyeri*. According to our extensive observation, the venation in the population JIN is not always palmate. The basal lateral veins are often close and do not always run parallel to the tip (Fig. 2B). Similar venation patterns frequently appear in the populations TAI, SHM, and TIA. Furthermore, the population JIN is closely allied to the populations TAI, TIA, and QIN in the PCO plot (Fig. 4). Therefore the population JIN is here included in subspecies *microphylla*.

Because *Syringa meyeri* was described from a cultivated plant in Beijing, we chose the type specimen, two specimens determined as *S. meyeri* by M. C. Chang (PE), and a cultivated plant from Beijing Botanical Garden as population MEY for analysis. In the PCO plot (Fig. 4), the type specimen of *S. meyeri* is closer to *S. pubescens* subsp. *pubescens* (BAI, HEN), while the two specimens from PE have closer relationships with subspecies *microphylla*. Because no distinct characters can delimit *S. meyeri* from the others, we treat *S. meyeri* as a new synonym of *S. pubescens* subsp. *pubescens*.

TAXONOMIC TREATMENT

Three subspecies are recognized in *Syringa pubescens*: subspecies *pubescens*, subspecies *microphylla*, and subspecies *patula*.

1. **Syringa pubescens** Turcz., Bull. Soc. Imp. Naturalistes Moscou 13: 73. 1840. TYPE: China. Hebei Prov.: 1831, *P. J. Kirilov s.n.* (holotype, LE!, photo PE!).

Leaves 1.2–10 × 0.7–6 cm, glabrous or pubescent, lateral veins in 3 to 5 pairs; petioles 0.3–1.5 cm. Panicles lateral; inflorescence rachises 4-angled or terete, glabrous or pubescent. Calyces glabrous or pubescent; corolla tubes cylindrical or funnel-shaped, 4.5–16 mm, corolla throats 0.8–3 mm wide; anthers purple or rarely yellow, 0–4 mm below corolla throat. Capsules 6–20 × 2–6 mm, verrucose.

Syringa pubescens is distributed on the Korean Peninsula and in China. The taxon typically flowers in May. Chromosome number 2*n* – 46, 48.

KEY TO THE THREE SUBSPECIES OF *SYRINGA PUBESCENS*

1a. Corolla tube funnel-shaped with corolla throat (1.2–) 1.6–2.5(–3) mm diam.; leaf blades (3.7–) 4.4–8.2(–10) cm long . . . . subsp. *patula*
1b. Corolla tube cylindrical with corolla throat (0.8–) 0.9–2(–2.8) mm diam.; leaf blades (1.2–)1.5–6(–7) cm long.
2a. Inflorescence rachises glabrous or rarely pubescent, obviously 4-angled; leaf blades usually (3–)3.5–5.4 (–6) cm long . . . . subsp. *pubescens*
2b. Inflorescence rachises pubescent, faintly 4-angled or subterete; leaf blades usually (1.2–)1.5–6(–7) cm long . . . . subsp. *microphylla*

1a. **Syringa pubescens** subsp. **pubescens**

Syringa meyeri C. K. Schneid., Pl. Wilson. (Sargent) 1: 301. 1912. Syn. nov. TYPE: China. Beijing: Fengtai in cultivation, June 1910, *F. N. Meyer 23032* (holotype, A!).

Syringa wulingensis Skvortsov & W. Wang, Ill. Fl. Ligneous Pl. N. E. China: 566. 1955. TYPE: China. Hebei Prov.: Mt. Wulingshan, 4 Sep. 1952, *T. N. Liou 4737* (holotype, IFP!).

Leaves 3–6 × 1.7–4.2 cm, glabrous adaxially, glabrous or sparsely pubescent abaxially, veins pinnate or somewhat acrodromous. Inflorescence rachises obviously 4-angled, glabrous or rarely pubescent; calyces glabrous; corolla tubes cylindrical, 7–16.5 mm, throats 1–2.8 mm wide; anthers 0.5–4 mm below corolla throat.

Distribution and habitat. Subspecies *pubescens* is distributed in Nei Mongol (Inner Mongolia), Beijing, Hebei, Shanxi, Shaanxi, Henan, and Shandong in China. It usually grows in semi-shaded, moist deciduous forests, commonly at high altitudes up to 2400 m.

Discussion. Syringa meyeri was described by Schneider (1913) as new, and was stated to differ from *S. pubescens* in having two pairs of lateral veins running to the leaf tip. Green and Chang (1995) further described *S. meyeri* with two pairs of veins more or less palmately arranged at the base. But our careful observation showed that venation in *S. meyeri* was not distinguished from that in *S. pubescens* subsp. *pubescens* (Fig. 2A). Furthermore, no distinct characters differentiate the two taxa. We propose that *S. meyeri* is only an extreme cultivated variety in *S. pubescens* subsp. *pubescens* because *S. meyeri* was described from a cultivated plant in Beijing and no wild plants have been found so far.

Representative specimens examined. CHINA. **Beijing:** Mentougou, Baihuashan, *T. F. King 70* (PE); Miyun, *Ecology group 810* (PE). **Hebei:** Chicheng, *s. coll. 4164* (PE); Laishui, *K. M. Liou 2199* (PE); Laiyuan, *K. M. Liou 2367* (PE); Neiqiu, *X. Y. Liu 158* (PE); Wanping, *C. G. Yang 1261* (PE); Wu'an, *K. C. Kuan 5790* (PE); Xinglong, Wulingshan, *T. N. Liou 4779, 6633* (PE); Yixian, Yunmengshan, *K. M. Liou 2094* (PE); Yuxian, Xiaowutaishan, *H. W. Kung 51* (PE); Zhuolu, Xilingshan, *C. G. Yang 847* (PE); Zunhua, Dongling, *T. Tang 1773* (PE). **Henan:** Linbao, *Puchabiaoben 14261, 14632* (PE); Lushi, Laojunshan, *K. M. Liou 5047* (PE); Songxian, Wumasi, *Henandui 1505* (PE); Xixia, Laojunshan, *K. C Kuan & T. L. Dai 1584* (PE). **Nei Mongol (Inner Mongolia):** *A. David 1797* (K, P), s.d., *P. Arteselaer s.n.* (K). **Shaanxi:** Huayin, Huashan, *J. Y. Chen 03149, 03157* (PE), *W. Y. Hsia 4230* (PE), *T. N. Liou 10833* (PE), *Z. B. Wang 19646* (PE); Chang'an, Gangou, *B. Z. Guo 1108* (PE). **Shandong:** Tai'an, Taishan, *J. Y. Chen 04210, 04211* (PE), *Zhongdedui 674* (PE). **Shanxi:** Huoxian, Huoyueshan, *T. P. Wang 2583* (PE), Lingkongshan, *K. C. Kuan & Y. L. Chen 310* (PE), Qiliyu, *Yellow River Exped. 785* (PE); Hunyuan, Hengshan, *J. Y. Chen 03207, 03214* (PE), *Y. W. Tsui 2556* (PE); Qingyuan, Paoquan, *K. M. Liou 7801* (PE); Wutai, Erdaohe, *K. C. Kuan & Y. L. Chen 1653* (PE), Wutaishan, *D. Zheng 2073* (PE); Xiegan, Xuehuashan, *Yellow River Exped. 407* (PE); Yuanqu, Huangguman, *S. Y. Bao 2231* (PE).

1b. **Syringa pubescens** subsp. **microphylla** (Diels) M. C. Chang & X. L. Chen, Invest. Stud. Nat. 10: 34. 1990. Basionym: *Syringa microphylla* Diels, Bot. Jahrb. Syst. 29: 531. 1901. TYPE: China. Shaanxi: Tui kio shan, Lao yu he, Oct. 1896, *G. Giraldi 1644* (lectotype, designated here, FI!).

Syringa microphylla var. *flavoanthera* X. L. Chen, Bull. Bot. Res., Harbin 9(3): 41. 1989. *Syringa pubescens* subsp. *microphylla* var. *flavoanthera* (X. L. Chen) M. C. Chang, Fl. Reipubl. Popularis Sin. 61: 68. 1992. TYPE: China. Shaanxi: Foping, Longcaoping, 1900 m, s.d., *X. L. Chen 0035* (holotype, NWFC not seen).

Syringa microphylla var. *glabriuscula* C. K. Schneid., Pl. Wilson. (Sargent) 1: 301. 1913. TYPE: China. Hubei: Mt. Miao-uan-san, 1898, *H. Scallan s.n.* (holotype, A not seen).

Syringa pubescens var. *tibetica* Batalin, Trudy Imp. S.-Peterburgsk. Bot. Sada 13 (18): 378. 1894. TYPE: China. Gansu: Huidui, 7200 ft., 7 May 1885, *G. N. Potanin s.n.* (holotype, LE not seen).

Syringa dielsiana C. K. Schneid., Bot. Jahrb. Syst. 36(5, Beibl. 82): 88. 1905. TYPE: China. Shaanxi: Qin ling, 10 June 1900, *G. Giraldi 7193* (lectotype, designated here, FI!).

Syringa giraldiana C. K. Schneid., Bot. Jahrb. Syst. 36(5, Beibl. 82): 88. 1905. *Syringa microphylla* var. *giraldiana* (C. K. Schneid.) S. Z. Qu & X. L. Chen, Bull. Bot. Res., Harbin 9(3): 41. 1989. TYPE: China. Shaanxi: Liu siu shan, Aug. 1899, *G. Giraldi 4405* (holotype, FI!).

Syringa potaninii C. K. Schneid., Repert. Spec. Nov. Regni Veg. 9: 80. 1910. *Syringa pubescens* subsp. *microphylla* var. *potaninii* (C. K. Schneid.) P. S. Green & M. C. Chang, Novon 5: 332. 1995. TYPE: China. Gansu: Tschi lo ku, 18 June 1885, *G. N. Potanin s.n.* (holotype, LE!, photo PE!).

Syringa julianae C. K. Schneid., Ill. Handb. Laubholzk. 2: 777. 1911. Syn. nov. *Syringa pubescens* subsp. *julianae* (C. K. Schneid.) M. C. Chang & X. L. Chen, Invest. Stud. Nat. 10: 34. 1990. TYPE: China. Hubei: Fangxian, 26 May 1911, *E. H. Wilson 1220A* (holotype, K!).

Syringa verrucosa C. K. Schneid., Pl. Wilson. (Sargent): 1: 298. 1912. TYPE: China. Hubei: Xingshan Co., Mt. Wentsao, 2300 m, 5 June 1907, *E. H. Wilson 2579* (holotype, A not seen; isotype, K!).

Syringa schneideri Lingelsh., Pflanzenr. (Engler) 72 (IV 243): 86. 1920. TYPE: China. Hubei: June 1907, *E. H. Wilson 2024* (holotype, K!; isotype, E!).

Syringa trichophylla Tang, Bull. Fan. Mem. Inst. Biol. Bot. 10: 287. 1941. TYPE: China. Shanxi: Taigu, Fengshan, 400 m, 11 May 1929, *T. Tang s.n.* (holotype, A not seen).

Syringa meyeri var. *spontanea* M. C. Chang, Invest. Stud. Nat. 10: 33. 1990. Syn. nov. *Syringa spontanea* (M. C. Chang) X. K. Qin, Acta Phytotax. Sin. 36(4): 362. 1998. TYPE: China. Liaoning: Jinzhou, Heshang shan (Dahei shan), 500 m, 12 Sep. 1989, *M. C. Chang & X. K. Qin 12872* (holotype, SHM!, photos K!, PE!).

Leaves 1.2–7 × 0.7–4 cm, glabrous or pubescent. Inflorescence rachises pubescent, 4-angled or subterete. Calyces pubescent or glabrous; corolla tubes 4.5–14 mm, throats 0.8–2 mm wide; anthers purple or rarely yellow, 0–3 mm below corolla throat.

Distribution and habitat. *Syringa pubescens* subsp. *microphylla* is distributed in Qinghai, Gansu, Shaanxi, Chongqing, Hubei, Shanxi, Henan, Shandong, and Liaoning provinces. It usually occurs in dry, open scrub or at the margins of semi-shade forest and commonly grows at lower altitudes than subspecies *pubescens*.

Discussion. Two lectotypes were designated here. Diels (1901) described *Syringa microphylla* as new and cited two specimens, *G. Giraldi 1644* and *1645*, both of which were from Tui kio shan of Shaanxi Province. We chose *G. Giraldi 1644* as the lectotype here. Schneider (1905) described *S. dielsiana* as new and cited two specimens, *G. Giraldi 7193* (with flowers) and *741* (with fruit) from Shaanxi Province. We selected the flowering specimen as the lectotype here.

Syringa julianae was described by Schneider (1911) based on a specimen from Hubei Province, which was treated as *S. pubescens* subsp. *julianae* by Chang and Chen (1990). In the PCO plot (Fig. 4), most specimens from the region of the type locality (OTH) are close to those in *S. pubescens* subsp. *microphylla*. The characters previously used to delimit *S. julianae*, such as the shape of the corolla tubes and anther insertion on corolla tubes, are not discrete in the analysis. Thus, *S. julianae* is newly placed in synonymy with *S. pubescens* subsp. *microphylla*.

Syringa meyeri var. *spontanea* was described by Chang and Chen (1990) on the basis of its venation being similar to that of *S. meyeri*. Qin (1998) even treated it as a separate species, *S. spontanea*, based on its palmate venation. According to our extensive observation, the venation in *S. meyeri* var. *spontanea* is not always palmate. Both palmate and pinnate venations were observed in the type locality (JIN), even in the type specimen (Fig. 2B). Similar venation patterns were observed in Mt. Tianlong (SHM) and Mt. Tai (TAI). Thus, it is not reliable to establish the new taxon based on the venation. *Syringa meyeri* var. *spontanea* resembles *S. pubescens* subsp. *microphylla* in the size and shape of the leaf blades and in the indumentum on the inflorescence rachises and calyces. Breeding experiments in Beijing Botanical Garden showed that *S. meyeri* var. *spontanea* and *S. pubescens* subsp. *microphylla* are interfertile, indicating their close affinity. Therefore, *S. meyeri* var. *spontanea* is here included as a synonym of *S. pubescens* subsp. *microphylla*, which is in accordance with the PCO plot (Fig. 4).

Representative specimens examined. CHINA. **Chongqing:** Chengkou, *P. G. Farges 885* (K). **Gansu:** Pingliang, Kongtongshan, *J. Y. Chen 03171, 03175* (PE); Tianshui, Guanyinya, *Q. S. Li 260* (PE), Putaoyuan, *J. Y. Chen 04035, 04044* (PE), Xiaolongshan, *Yellow River Exped. 3657* (PE); Wushan, Laojunshan, *Yellow River Exped. 4187* (PE). **Henan:** Dengfeng, *s. coll. 51644* (PE); Songxian, Xizhuanghe, *Henan Linyeting 853, 857* (PE); Xixia, Funiushan, *Henan Linyeting 1376* (PE), Laocangling, *K. C. Kuan & T. L. Dai 1148* (PE); Yichuan, *Puchabiaoben 20296, 21100* (PE). **Hubei:** Badong, *A. Henry 6985* (K); Shiyan, Saiwudang, *Z. E. Zhao 2055* (HIB); Yunxi, Tianfengshan, *J. X. Yang 2540* (PE). **Liaoning:** Jinzhou, *M. C. Chang & X. K. Qin 12878* (K, SHM), *J. Y. Chen 03117, 03129* (PE), *T. N. Liou 192* (IFP). **Qinghai:** Huzhu, *S. P. Wang 041* (HNWP); Minhe, Gushan, *B. Z. Guo & B. W. Li 8461* (HNWP); Xiji, Huoshizhai, *L. H. Zhou 2888* (HNWP). **Shaanxi:** Chang'an, Cuihuashan, *Gansu Yifendui 39* (PE), Nanwutai, *T. N. Liou 199, 11050* (PE); Huayin, Huashan, *J. Y. Chen 03143, 03144* (PE); Huxian, Laoyu, *J. Y. Chen 03041* (PE), Zhuque, *J. Y. Chen 03159, 03167* (PE); Foping, Laojunling, *B. Z. Guo 1408* (PE); Ningshan, Huoditang, *J. Y. Chen 05090, 05095* (PE); Shangxian, Heishanjie, *T. P. Wang 16069* (PE); Shanyang, Xiaohekou, *Z. Y. Zhang 15953* (PE), Yugang gongshe, *J. X. Yang & Y. M. Liang 2807, 2847* (PE); Taibaishan, Dadian, *Y. Y. Pai 1579* (PE), Haopingsi, *J. X. Yang 206* (PE), *J. Y. Chen 03022, 03024* (PE), Jiaolongsi, *J. X. Yang 281, 285* (PE), Liujiacun, *K. T. Fu 82, 2458* (PE), Xiabaiyun, *J. X. Yang 154* (PE). **Shandong:** Tai'an, Taishan, *J. Y. Chen 04207, 04209* (PE), *Shandong Agriculture University 818* (PE), *X. S. Wen 890064* (SDNU), *Zhongdedui 674* (PE). **Shanxi:** Huoxian, Qiliyu, *Yellow River Exped. 702* (PE); Linchuan, *K. M. Liou 7667* (PE); Qingyuan, Paoquan, *K. M. Liou 1391* (PE); Ruicheng, Baiquancun, *S. Y. Bao 544* (PE); Taiyuan, *J. Y. Chen 04101, 04102* (PE), Huyancun, *Y. Yabe s.n.* (PE); Xiegan, Xuehuashan, *Yellow River Exped. 585* (PE); Yicheng, *X. Y. Liu 20370* (PE); Yongji, *T. W. Liu 0038, 0221* (PE); Yuanqu, Tongshan township, *S. Y. Bao 66* (PE).

1c. Syringa pubescens subsp. **patula** (Palib.) M. C. Chang & X. L. Chen, Invest. Stud.

Nat. 10: 34. 1990. Basionym: *Ligustrum patulum* Palib., Trudy Imp. S.-Peterburgsk. Bot. Sada 18(2): 156. 1900. *Syringa patula* (Palib.) Nakai, J. Jap. Bot. 14: 638. 1938. TYPE: Korea. Kyong-Kwi, Seoul prope Tap-Tong, 20 May 1895, *A. Sontag s.n.* (holotype, LE not seen).

Syringa velutina Kom., Trudy Imp. S.-Peterburgsk. Bot. Sada 18(6): 428. 1901. TYPE: Korea. Musang, Kosari-pi valley, 22 May 1897, *V. L. Komarov 1259* (holotype, LE not seen; isotypes, K!, FI!).

Syringa koehneana C. K. Schneid., Ill. Handb. Laubholzk. 2: 1063, fig. 627. 1912. TYPE: Fig. 627 in Schneider, 1912: 1063.

Syringa palibiniana Nakai, Bot. Mag. (Tokyo) 27: 32. 1913. TYPE: Korea. s. loc., Sep. 1901, *U. Faurie s.n.* (holotype, TI not seen).

Syringa micrantha Nakai, Bot. Mag. (Tokyo) 32: 129. 1918. TYPE: Korea. Kosuiin, 23 June 1917, *M. Furumi 65* (holotype, TI not seen).

Syringa kamibayashii Nakai, Bot. Mag. (Tokyo) 32: 130. 1918. TYPE: Korea. Dohosan, s.d., *K. Kamibayashi s.n.* (holotype, TI not seen).

Syringa venosa Nakai, Bot. Mag. (Tokyo) 32: 130. 1918. TYPE: Korea. Ooryongto, 3 June 1917, *T. Nakai 4194* (lectotype, designated here, TI!).

Syringa debelderorum J. L. Fiala, Lilacs, Gen. Syringa: 48. 1988, as *S. debelderi*. *Syringa pubescens* subsp. *patula* 'De Belder,' Quart. J. Int. Lilac Soc. 33(4): 123. 2004. TYPE: South Korea. Mt. Sorak National Park, 1977, *National Arboretum 41179* (holotype, US not seen).

Leaves 3.7–10 × 1.9–6 cm, glabrous or pubescent. Inflorescence rachises 4-angled, glabrous or pubescent. Calyces toothed, glabrous or pubescent; corolla tubes funnel-formed, 5–13 mm, throats (1.2–)1.6–2.5(–3) mm wide; anthers (0–)0.1–0.9(–1) mm below corolla throat.

Distribution and habitat. The distribution of *Syringa pubescens* subsp. *patula* is in the Korean Peninsula and northeastern China (Liaoning Province). It grows in deciduous forests or along forest margins.

Discussion. One lectotype was designated here. Nakai (1918) described *Syringa venosa* as new and cited five specimens from Ooryongto. We chose one of Nakai's collections with flowers, *T. Nakai 4194*, as the lectotype here.

Syringa debelderi J. L. Fiala was described from a cultivated plant that was stated to have small leaf blades (7 × 5 cm) (Fiala, 1988). The name was corrected as *S. debelderorum* J. L. Fiala by Green (1989). The size of leaf blades and other characters of *S. debelderorum* are scarcely different from *S. pubescens* subsp. *patula*.

Representative specimens examined. CHINA. **Liaoning:** Benxi, *C. S. Wang 4390* (PE); Dandong, *J. Y. Chen 04107, 04113* (PE); Fengcheng, *J. Y. Chen 03248* (PE); Qianshan, *Y. C. Chu 576* (PE); Xiuyan, *W. Wang 1556, 1576* (PE). KOREA. **s. loc.:** *V. L. Komarov 1259* (K), *J. Sato 4147* (PE), *J. Sato 4150* (PE), *E. H. Wilson 11705* (PE); Doekyu-san, *Hagman 329* (UPS); Kongo-san, *E. H. Wilson 10491* (K); Mt. Chiisan, *J. Ohwi 6811* (UPS); Shuotsu, *J. Ohwi 380* (UPS); Sorak-san, *Elsik & Hey 915-77* (K); Chonranam-do, *H. T. Im 22226* (TI); Dagelet island, *E. H. Wilson 8527* (K); Keiki, Poukhan-san, *E. H. Wilson 10741* (K); Ooryonto, *T. Nakai 4194* (TI).

Literature Cited

Chang, M. C. 1992. *Syringa*. Pp. 50–84 *in* Flora Reipublicae Popularis Sinicae, Vol. 61. Science Press, Beijing.

——— & X. L. Chen. 1990. Studies on Chinese *Syringa* 1. Invest. Stud. Nat. 10: 32–40.

——— & P. S. Green. 1996. *Syringa*. Pp. 280–286 *in* Z. Y. Wu & P. H. Raven (editors), Flora of China, Vol. 15: Myrsinaceae through Loganiaceae. Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis.

Chen, X. L., X. Y. Zhao & S. Z. Qu. 1989. New materials for genus *Syringa* L. Bull. Bot. Res., Harbin 9(3): 39–41.

Diels, F. L. 1901. Die Flora von Central-China. Bot. Jahrb. Syst. 19: 531–532.

Fiala, J. L. 1988. Lilacs: The Genus *Syringa*. Timber Press, Portland.

Green, P. S. 1989. Lilacs: The Genus *Syringa* [book review]. Kew Mag. 6(2): 90–92.

——— & M. C. Chang. 1995. Some taxonomic changes in *Syringa* L. (Oleaceae), including a revision of series *Pubescentes*. Novon 5: 329–333.

Komarov, V. L. 1901. Species novae Florae Asiae Orientalis (Manshuriae et Koreae borealis). Trudy Imp. S.-Peterburgsk. Bot. Sada 18: 428.

Lingelsheim, A. 1920. *Syringa*. Pp. 75–95 *in* A. Engler (editor), Das Pflanzenreich, Vol. 72(IV 243). Wilhelm Engelmann, Leipzig.

McKelvey, S. D. 1928. The Lilac: A Monograph. The Macmillan Company, New York.

Nakai, T. 1913. Notulae ad Plantas Japoniae et Coreae. Bot. Mag. (Tokyo) 27: 32–33.

———. 1918. Flora Sylvatica Koreana 10. Bot. Mag. (Tokyo) 32: 124–133.

Palibin, I. 1900. Conspectus Florae Koreae, Part 2. Trudy Imp. S.-Peterburgsk. Bot. Sada 18: 156.

Qin, X. K. 1998. Notes on *Syringa meyeri* Schneid. and its confused species. Acta Phytotax. Sin. 36: 359–364.

Schneider, C. K. 1905. *Syringa*. *In* F. L. Diels, Beiträge zur Flora des Tsin ling shan und andere zusätze zur Flora von Central-China. Bot. Jahrb. Syst. 36(5, Beibl. 82): 86–89.

———. 1910. Species et formae novae generis *Syringa*. Repert. Spec. Nov. Regni Veg. 9: 79–82.

———. 1911. Illustriertes Handbuch der Laubholzkunde (Band II): 771–785. Gustav Fisher, Jena.

———. 1912. Illustriertes Handbuch der Laubholzkunde (Band II): 1063. Gustav Fisher, Jena.

———. 1913. *Syringa*. 297–301, *in* Plantae Wilsonianae (Sargent), Vol. 1. Cambridge University Press, Cambridge

Skvortzov, B. V. & W. Wang. 1955. Oleaceae. Pp. 471–567 *in* T. N. Liou (editor), Ill. Fl. Ligneous Pl. N. E. China. Science Press, Beijing.

Tang, T. 1941. A new species of *Syringa* in Shanxi. Bull. Fan Mem. Inst. Biol. Bot. 10: 288.

Turczaninow, N. 1840. Decades Quatuor Plantarum Hucusque Descriptarum Sibiriae. Bull. Soc. Imp. Naturalistes Moscou 13: 73.

APPENDIX 1. The coding of morphological characters used in the analysis of the *Syringa pubescens* complex.

Continuous characters: 1. Length of leaf blades (cm). 2. Width of leaf blades (cm). 3. Ratio of length:width of leaf blades. 4. Number of lateral vein pairs. 5. Length of petioles (cm). 6. Length of inflorescences (cm). 7. Diameter of inflorescences (cm). 8. Number of flowers per inflorescence. 9. Length of calyces (mm). 10. Diameter of calyces (mm). 11. Length of corolla tubes (mm). 12. Diameter of corolla throats (mm). 13. Shape of corolla tube [CTS = (diameter of corolla throat – diameter of corolla base) / length of corolla tube]. 14. Length of corolla lobes (mm). 15. Width of corolla lobes (mm). 16. Anther position at corolla tube from base (mm). 17. Distance between anthers and corolla throat (mm). 18. Pistil length (mm).

Binary characters: 1. Adaxial leaf surface flat (0); concave (1). 2. Abaxial leaf surface flat (0); convex (1). 3. Calyx lobes truncate (0); toothed (1).

Ordinal characters: 1. Indumentum coverage on adaxial leaf surface 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4). 2. Indumentum coverage on abaxial leaf surface 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4). 3. Basal veins pinnate (1); connate (2); acrodromous basal (3). 4. Indumentum coverage on petioles 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4). 5. Shape of inflorescence rachises terete (1); 4-angular (2); irregular (3). 6. Indumentum coverage on inflorescence rachises 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4). 7. Lenticel coverage on inflorescence rachises 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4). 8. Indumentum coverage on calyces 0 (0); 0%–5% (1); 5%–25% (2); 25%–75% (3); 75%–100% (4).